

DESCRIPTION

5 OPTICAL COMPENSATION PLATE,
 POLARIZING PLATE USING THE SAME AND
IMAGE DISPLAY APPARATUS USING THE SAME

Technical Field

[0001] The present invention relates to an optical compensation plate, a polarizing plate using the same and an image display apparatus using the
10 same.

Background Art

[0002] In a liquid crystal display, both surfaces of a liquid crystal cell in which a liquid crystal is retained are generally provided with a polarizer.
15 In order to visually compensate for retardation caused by birefringence of the liquid crystal cell in a front direction and a slanting direction, a birefringent layer is further disposed as an optical compensation layer between the liquid crystal cell and the polarizer. As this birefringent layer, a negative birefringent layer that is obtained by aligning cholesteric liquid
20 crystal molecules on an alignment substrate and whose refractive indices (n_x, n_y, n_z) satisfy a negative uniaxiality " $n_x = n_y > n_z$ " usually is used. The refractive indices (n_x, n_y, n_z) respectively indicate refractive indices in three axial directions in the birefringent layer. The axial directions of the refractive indices (n_x, n_y, n_z) in the birefringent layer are indicated
25 specifically by arrows in a schematic view of FIG. 1. As mentioned above, the refractive indices n_x, n_y, n_z respectively indicate refractive indices in an X-axis direction, a Y-axis direction and a Z-axis direction. As shown in the figure, the X-axis direction is an axial direction exhibiting a maximum refractive index within the plane, the Y-axis direction is an axial direction
30 perpendicular to the X axis within the plane, and the Z-axis direction is a

thickness direction perpendicular to the X axis and the Y axis.

- [0003] As the optical compensation layer, for example, an optical compensation layer is reported, which is provided by forming an alignment film on a support and inclinedly aligning a discotic liquid crystal on this alignment film (see, for example, Patent document 1, and Patent document 2).

- [0004] It has been also reported that a cholesteric liquid crystal layer is formed by applying a liquid crystal polymer onto an alignment substrate and aligning the liquid crystal polymer, and that the cholesteric liquid crystal layer is used as an optical compensation layer (see Patent document 3, for example).

[0005] Patent document 1: Japanese Patent 2692035

Patent document 2: Japanese Patent 2802719

Patent document 3: Japanese Patent 2660601

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Disclosure of Invention

- [0006] However, the optical compensation layer formed of the cholesteric layer as described above had a problem that cracks (for example, breaks, fractures and the like) occur when a pressure is locally applied by, for example, a shake or the like during transportation. Also, the optical compensation layer had a problem that distortion occurs due to applied heat, moisture or the like, and display irregularity occurs within the plane.

- [0007] In the light of the above-mentioned problems, the object of the present invention is to provide an optical compensation plate including the optical compensation layer in which the occurrence of display irregularity within the plane is suppressed by, for example, preventing the occurrence of cracks due to a shake, applied pressure or the like and the distortion of the optical compensation layer caused by applied heat, moisture or the like.

- Moreover, the further object of the present invention is to provide a polarizing plate including the optical compensation plate and various image

display apparatuses including the optical compensation plates.

[0008] In order to attain the above-mentioned object, the optical compensation plate of the present invention is an optical compensation plate including an optical compensation layer, wherein an anti-cracking layer

5 containing a moisture-curing isocyanate compound is laminated directly on at least one surface of the optical compensation layer, and a glass transition temperature (Tg) of the anti-cracking layer is 100°C or less in a cured state. In addition, the polarizing plate of the present invention includes a polarizer, a transparent protective layer and the optical compensation plate of the 10 present invention.

[0009] By providing an adhesive layer (that is, the anti-cracking layer), which includes a moisture-curing isocyanate compound and has a glass transition temperature of 100°C or less in a cured state, directly on at least one surface of the optical compensation layer, as mentioned above, the

15 distortion of the optical compensation layer caused by, for example, applied heat, moisture or the like can be suppressed. Therefore, according to the optical compensation plate of the present invention, when used for various image display apparatuses, the occurrence of the display irregularity within the plane can be suppressed, whereby an excellent display property can be 20 realized.

Brief Description of Drawings

[0010] FIG. 1 is a schematic view showing axial directions of refractive indices.

25 FIG. 2 is a view describing a method for measuring display irregularity.

Description of the Invention

[0011] As mentioned above, the optical compensation plate of the present 30 invention includes an optical compensation layer, in which an anti-cracking

layer that is laminated on the optical compensation layer has a glass transition temperature (Tg) of 100°C or less in a cured state.

[0012] In addition, the anti-cracking layer may be laminated on one surface of the optical compensation layer or both surfaces thereof. Even in 5 the case of laminating the anti-cracking layer on only one surface of the optical compensation layer, the occurrence of cracks can be suppressed sufficiently, and the optical compensation plate of the present invention further can be thinned. Whereas, in the case of laminating the anti-cracking layers on both surfaces of the optical compensation layer, 10 durability against shakes and applied pressure can be enhanced more, and thus the occurrence of cracks can be suppressed more.

[0013] The anti-cracking layer is formed of an adhesive that contains a moisture-curing isocyanate compound (hereinafter, also called an adhesive containing a moisture-curing isocyanate compound), and a glass transition 15 temperature thereof is 100°C or less, and preferably is 60°C or less. The lower limit of the glass transition temperature is not particularly limited, but preferably is 0°C or more, for example.

[0014] The glass transition temperature is determined by a peak value of tan δ that is provided by a result of viscoelasticity measurement at 20 temperatures ranging from -30°C to 200°C, which is obtained by using, for example, a visco-elastometer ARES manufactured by TA INSTRUMENTS JAPAN. The method thereof will be described below in detail.

[0015] The moisture-curing isocyanate compound is not particularly limited in kind, as long as the glass transition temperature of the formed 25 anti-cracking layer may be 100°C or less, and for example, aromatic-type, aliphatic-type or cycloaliphatic-type may be used. Here, these compounds may be monomers or polymers, and may be used alone or in combination of two kinds or more.

[0016] Specific examples of the moisture-curing isocyanate compound 30 include hexamethylenediisocyanate, 1,3-bis(isocyanatomethyl)cyclohexane

and the like. Among them, hexamethylenediisocyanate is particularly preferable because of having a lower glass transition temperature.

[0017] In addition, a content ratio of the moisture-curing isocyanate compound in the anti-cracking layer ranges, for example, from 90 wt% to 5 100 wt% by solid weight, preferably ranges from 95 wt% to 100 wt%, and more preferably ranges from 98 wt% to 100 wt%. The anti-cracking layer may contain other components besides the moisture-curing isocyanate compound.

[0018] A thickness of the anti-cracking layer preferably ranges, for 10 example, from 0.1 μm to 20 μm , more preferably ranges from 0.5 μm to 15 μm , and particularly preferably ranges from 1 μm to 10 μm .

[0019] In addition, microhardness of the anti-cracking layer preferably ranges, for example, from 0.1 GPa to 0.5 GPa, more preferably ranges from 0.2 GPa to 0.5 GPa, and particularly preferably ranges from 0.3 GPa to 0.4 15 GPa. Here, since the correlation between the microhardness and Vickers hardness is known, the microhardness can be expressed in terms of Vickers hardness.

[0020] The microhardness can be calculated from an indentation deepness and an indentation load, by using, for example, a thin film hardness meter 20 (trade name: MH4000, MHA-400 or the like) manufactured by NEC Corporation.

[0021] The optical compensation plate of the present invention can be manufactured, for example, in the below-described manners.

[0022] First, a solution of the adhesive containing the moisture-curing 25 isocyanate compound is prepared by dissolving or dispersing the above-described various kinds of moisture-curing isocyanate compounds into a solvent. Then, the solution is applied onto an optical compensation layer that is prepared in advance, and is cured so as to form the anti-cracking layer, thereby obtaining the optical compensation plate in 30 which the anti-cracking layer is laminated directly on the optical

compensation layer.

[0023] The kind of the solvent can be determined suitably, for example, according to the kind of the moisture-curing isocyanate compound, and for example, ethyl acetate, methylethylketone, methylisobutylketone, toluene, xylene and the like can be used. A mixture of a plurality of these solvents may be used as necessary.

[0024] An amount of the adhesive containing the moisture-curing isocyanate compound to be applied onto the optical compensation layer can be determined suitably, for example, according to a required thickness of the anti-cracking layer to be formed.

[0025] The adhesive containing the moisture-curing isocyanate compound can be cured by, for example, reacting with water in the air, adsorbed water on the surface of an adherend or active hydrogen groups such as a hydroxyl group, a carboxyl group and the like. Thus, the adhesive containing the moisture-curing isocyanate compound may be cured naturally by the conventionally known method, for example, by applying the adhesive and leaving it. Here, the above-described solvent included in the adhesive may be volatilized by air drying or heat drying.

[0026] In the optical compensation plate of the present invention, the optical compensation layer is preferably a cholesteric layer whose constituent molecules are aligned in the form of a cholesteric structure.

[0027] In the present invention, the cholesteric layer also can be called a layer having a pseudo-layer structure, so-called a planar structure or a Granjean structure, in which the constituent molecules of the layer have a helical structure and a screw axis thereof is aligned substantially perpendicularly to the in-plane direction. Also, the state in which the "constituent molecules have a cholesteric structure" in the present invention is not limited to the state where liquid crystalline compounds are in a cholesteric liquid crystalline phase, for example, but also includes the state where non-liquid crystalline compounds are aligned in a helical manner as

in the cholesteric liquid crystalline phase. Incidentally, this state is not a liquid crystalline phase. Accordingly, the constituent molecules of the cholesteric layer can be, for example, liquid crystal polymers or non-liquid crystal polymers described below.

- 5 [0028] In the cholesteric layer, it is preferable that the above-mentioned refractive indices (n_x , n_y , n_z) in the three axial directions satisfy $n_x \approx n_y > n_z$, for example. An optical compensation plate including an optical compensation layer with such optical characteristics can be used as a so-called negative C-Plate retardation plate.
- 10 [0029] In the optical compensation plate of the present invention, the cholesteric layer has a selective reflection wavelength which ranges, for example, from 100 nm to 320 nm. The upper limit of the selective reflection wavelength range is preferably 300 nm or less. On the other hand, lower limit thereof is preferably 150 nm or more. When the selective reflection wavelength is in this range, for example, coloration of the cholesteric layer, light leakage in a crossed Nicol state and the like can be prevented sufficiently. Therefore, when the optical compensation plate of the present invention is used for various image display apparatuses, the superior display property can be provided both in the front direction and in
- 15 20 the slant direction.

[0030]. In the case where the cholesteric layer is formed using a liquid crystal monomer as described below, for example, a center wavelength of the selective reflection wavelength range λ (nm) can be expressed by the equation below.

25 $\lambda = n \cdot P$

In the above equation, n denotes an average refractive index of the liquid crystal monomer, and P denotes a helical pitch (μm) of the cholesteric layer. The average refractive index n is represented by " $(n_o + n_e)/2$ " and usually ranges from 1.45 to 1.65, with n_o denoting an ordinary refractive index of the liquid crystal monomer and n_e denoting an extraordinary

refractive index of the liquid crystal monomer.

[0031] A thickness of the cholesteric layer ranges, for example, from 0.5 μm to 10 μm , more preferably ranges from 1 μm to 8 μm , and particularly preferably ranges from 2 μm to 6 μm .

- 5 [0032] It is preferable that the cholesteric layer contains a chiral dopant. The chiral dopant in the present invention is, for example, a chemical compound having a function of aligning constituent compounds such as a liquid crystal monomer and/or a liquid crystal polymer described below so as to have a cholesteric structure.
- 10 [0033] The chiral dopant is not particularly limited in kind as long as it can align constituent molecules of the cholesteric layer to have a cholesteric structure as described above, but the chiral dopants that will be described below are preferable, for example.
- 15 [0034] In these chiral dopants, the helical twisting power thereof preferably is $1 \times 10^{-6} \text{ nm}^{-1} \cdot (\text{wt}\%)^{-1}$ or more, more preferably is $1 \times 10^{-5} \text{ nm}^{-1} \cdot (\text{wt}\%)^{-1}$ or more, further preferably ranges from 1×10^{-5} to $1 \times 10^{-2} \text{ nm}^{-1} \cdot (\text{wt}\%)^{-1}$, and particularly preferably ranges from 1×10^{-4} to $1 \times 10^{-3} \text{ nm}^{-1} \cdot (\text{wt}\%)^{-1}$. By using the chiral dopant with the above helical twisting power, for example, the helical pitch of the formed cholesteric layer can be controlled to be in the 20 below-noted range, making it duly possible to control the selective reflection wavelength range to be in the above-noted range.
- 25 [0035] In general, the helical twisting power refers to an ability to give a twist to liquid crystal materials such as a liquid crystal monomer and/or a liquid crystal polymer, which will be described below, thus aligning those materials in a helical manner, and is represented by the equation below.

Helical twisting power = $1 / [\text{Cholesteric pitch (nm)} \times \text{Weight ratio of chiral dopant (\text{wt}\%)}$]

- [0036] In the above equation, the weight ratio of chiral dopant refers to the ratio (weight ratio) of the chiral dopant in a mixture containing, for example, 30 a liquid crystal monomer and/or a liquid crystal polymer, and the chiral

dopant, and is represented by the equation below.

$$\text{Weight ratio of chiral dopant (wt\%)} = [X / (X + Y)] \times 100$$

X: Weight of chiral dopant

Y: Weight of liquid crystal monomer and/or liquid crystal

5 polymer

[0037] Further, the helical pitch in the cholesteric layer is, for example, 0.25 μm or less, preferably ranges from 0.01 μm to 0.25 μm , more preferably ranges from 0.03 μm to 0.20 μm , and particularly preferably ranges from 0.05 μm to 0.15 μm . The helical pitch of 0.01 μm or more provides, for example, a sufficient alignment, whereas the helical pitch of 0.25 μm or less, for example, can suppress optical rotatory power on a shorter wavelength side of visible light sufficiently, thus preventing light leakage sufficiently for use under polarized light. Also, by using the chiral dopant having the above-described helical twisting power, the helical pitch of the cholesteric layer formed can be controlled to be in the above-noted range.

[0038] In the cholesteric layer, a single hue b value is preferably, for example, 1.2 or less, more preferably is 1.1 or less, and particularly preferably is 1.0 or less. The cholesteric layer having a single hue b value in the above-noted range, for example, has significantly small coloration and provides truly excellent optical characteristics. The single hue b value in this range can be attained by, for example, controlling the selective reflection wavelength range to be in the above-noted range.

[0039] The single hue b value is defined by the Hunter Lab colorimetric system (Hunter, R.S.: J. Opt. Soc. Amer., 38, 661(A), 1094(A) (1948); J. Opt. Soc. Amer., 48, 985 (1958)). More specifically, in accordance with JIS K 7105 5.3, for example, tristimulus values (X, Y, Z) of a sample are measured using a spectrophotometer or a photoelectric colorimeter and substituted into the Hunter equation, which is shown below as a color difference equation in the L, a, b space, thereby calculating a single hue b value.

30 Usually, a C light source is used for this measurement, for example, using

an integrating-sphere spectral transmittance meter (trade name DOT-3C; manufactured by Murakami Color Research Laboratory).

$$\text{Single hue } b = 7.0 \times (Y - 0.847Z) / Y^{1/2}$$

- [0040] A specific example of the constituent molecules of the cholesteric layer is a non-liquid crystal polymer, and the non-liquid crystal polymer is preferably a polymer obtained by polymerizing or cross-linking liquid crystal monomers that are aligned in the form of a cholesteric structure. Since the liquid crystal monomer shows a liquid crystalline property as described below, the monomer can be aligned in the form of a cholesteric structure, and this alignment can be fixed by polymerizing the monomers.
- Therefore, although the liquid crystal monomer is used, the polymer that is polymerized by the above-mentioned fixing will have a non-liquid crystalline property. Here, for example, when the below-described chiral dopant is used to allow the liquid crystal monomers to have a cholesteric structure, the polymer will be a non-liquid crystal polymer that is obtained by polymerizing and cross-linking the liquid crystal monomers with the chiral dopant.
- [0041] As the constituent molecules of the cholesteric layer, the above-described non-liquid crystal polymer is preferable for the following reason. The cholesteric layer formed of the above-described non-liquid crystal polymer has a cholesteric structure as in a cholesteric liquid crystalline phase, but is not constituted of liquid crystal molecules as mentioned above. Therefore, there occurs no transformation peculiar to the liquid crystal molecules, i.e., between a liquid crystalline phase, a glassy phase and a crystalline phase due to temperature change. Consequently, since an extremely stable optical compensation layer whose cholesteric structure is not affected by temperature change can be achieved, the optical compensation plate of the present invention is useful as a retardation film for optical compensation, for example.
- [0042] It is preferable that the liquid crystal monomer is represented by the

chemical formula (1) below. Although such liquid crystal monomers generally are nematic liquid crystal monomers, the liquid crystal monomer of the present invention is given a twist by the chiral dopant and eventually achieves a cholesteric structure. Also, since the monomer needs to be 5 polymerized or cross-linked for fixing the alignment in the cholesteric layer, it is preferable that the monomer contains at least one of a polymerizable monomer and a cross-linkable monomer.

[0043] When using the liquid crystal monomer, it is preferable that the cholesteric layer further contains at least one of a polymerizing agent and a 10 cross-linking agent, and for example, a ultraviolet curing agent, a photocuring agent or a thermosetting agent can be used.

[0044] The ratio of the liquid crystal monomer in the cholesteric layer preferably ranges, for example, from 75 wt% to 95 wt%, and more preferably ranges from 80 wt% to 90 wt%. Also, the ratio of the chiral dopant to the 15 liquid crystal monomer preferably ranges from 5 wt% to 23 wt%, and more preferably ranges from 10 wt% to 20 wt%. Further, the ratio of the cross-linking agent or the polymerizing agent to the liquid crystal monomer preferably ranges from 0.1 wt% to 10 wt%, more preferably ranges from 0.5 wt% to 8 wt%, and particularly preferably ranges from 1 wt% to 5 wt%.

20 [0045] Also, examples of the constituent molecules of the cholesteric layer can include a liquid crystal polymer in addition to the non-liquid crystal polymer, and may be a cholesteric layer having the liquid crystal polymer aligned in the form of a cholesteric structure. The liquid crystal polymer can be selected from, for example, the various liquid crystal polymers 25 disclosed in Japanese Patent 2660601.

[0046] The optical compensation plate of the present invention may be formed of only the above-noted optical compensation layer and the anti-cracking layer, but may further include a substrate and a laminate including the cholesteric layer laminated on the substrate.

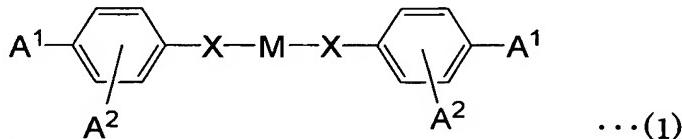
30 [0047] In the present invention, the optical compensation layer on which

the anti-cracking layer is laminated is not particularly limited in kind, but the cholesteric layer including non-liquid crystal polymers as constituent molecules as mentioned above can be prepared, for example, in the following method.

- 5 [0048] The method for manufacturing the cholesteric layer includes the steps of, for example, forming an expanded layer by expanding onto an alignment base a coating solution that contains a liquid crystal monomer, the chiral dopant and at least one of the polymerizing agent and the cross-linking agent,
- 10 subjecting the expanded layer a heat treatment so that the liquid crystal monomer can be aligned in the form of a cholesteric structure, and subjecting the expanded layer at least one of a polymerization treatment and a cross-linking treatment so as to fix the alignment of the liquid crystal monomer and form a cholesteric layer of the non-liquid crystal polymer.
- 15 [0049] First, the coating solution that contains the liquid crystal monomer, the chiral dopant and at least one of the cross-linking agent and the polymerizing agent is prepared.

- [0050] As the liquid crystal monomer, the nematic liquid crystal monomer is preferable, for example. More specifically, a monomer represented by the formula (1) below can be used. The liquid crystal monomer may be one kind or a combination of two or more kinds.

[0051] [Chemical formula 1]



25

- [0052] In the formula (1) above, each of A¹ and A² is a polymerizable group, and A¹ and A² may be identical or different. Alternatively, one of A¹ and A² may be hydrogen. X is each a single bond, -O-, -S-, -C=N-, -O-CO-,

--CO--O-- , --O--CO--O-- , --CO--NR-- , --NR--CO-- , --NR-- , --O--CO--NR-- ,
 --NR--CO--O-- , $\text{--CH}_2\text{--O--}$ or --NR--CO--NR , where R is H or C₁–C₄-alkyl and M
is a mesogenic group.

[0053] In the formula (1) above, Xs may be identical or different but

5 preferably are identical.

[0054] In the monomer of the formula (1) above, A² preferably is ortho to A¹
at each occurrence.

[0055] Further, it is preferable that A¹ and A² mentioned above are each,
independently from one another, represented by the chemical formula below.

10 Z – X – (Sp)_n (2)

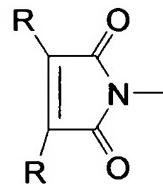
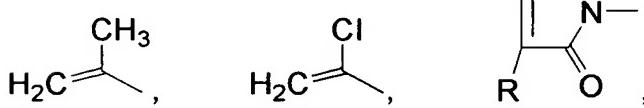
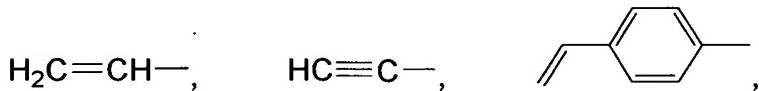
It is preferable that A¹ and A² are identical.

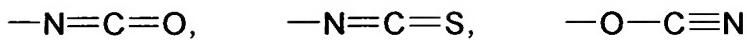
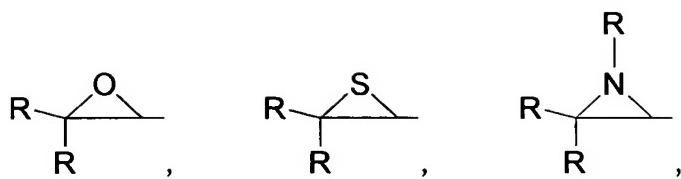
[0056] In the formula (2) above, Z is a crosslinkable group, X is similar to
that of the formula (1) above, Sp is a spacer formed of a straight-chain or
branched chain alkyl group having 1 to 30 carbon atoms, and n is 0 or 1.

15 The carbon chain in the Sp may be inserted by ether oxygen, thioether
sulfur, or nonadjacent imino group or C₁–C₄-alkylimino group.

[0057] In the formula (2) above, it is preferable that Z is any of the radicals
represented by the formulae below. In the formulae below, R is, for
example, methyl, ethyl, n-propyl, i-propyl, n-butyl, i-butyl or t-butyl.

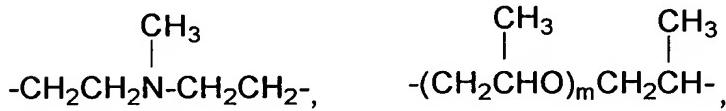
20 [0058] [Chemical formulae 2]





- 5 [0059] Also, in the formula (2) above, it is preferable that Sp is any of the radicals represented by the formulae below. In the formulae below, it is preferable that m is 1 to 3 and p is 1 to 12.

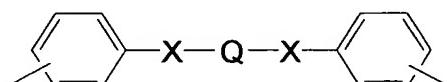
[0060] [Chemical formulae 3]



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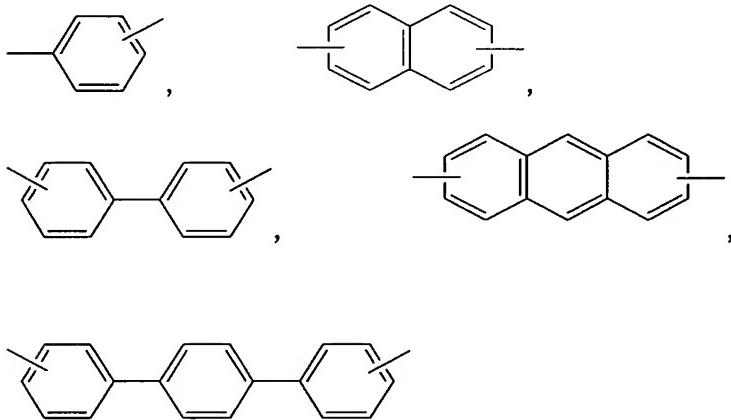
- [0061] In the formula (1) above, it is preferable that M is represented by formula (3) below. In the formula (3) below, X is similar to X in the formula (1) above. Q is, for example, substituted or unsubstituted alkylene or aromatic hydrocarbon radicals or may be a substituted or unsubstituted straight-chain or branched-chain C₁–C₁₂-alkylene.
- 20 [0062] [Chemical formulae 4]



... (3)

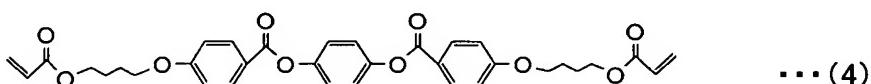
[0063] When Q is the aromatic hydrocarbon radicals, the radicals represented by the formulae below or substituted analogs thereof are preferable, for example.

5 [0064] [Chemical formulae 5]

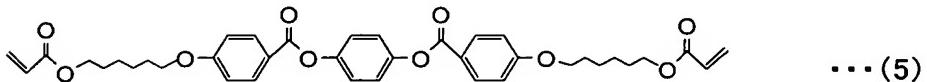


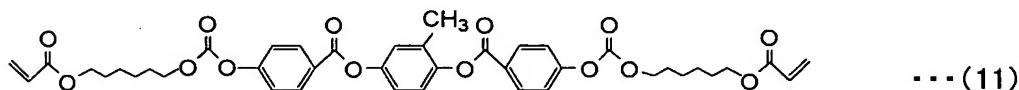
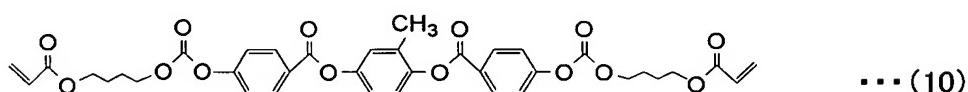
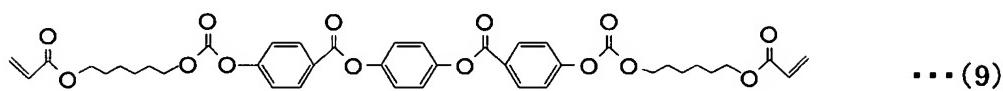
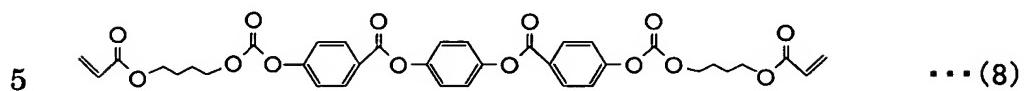
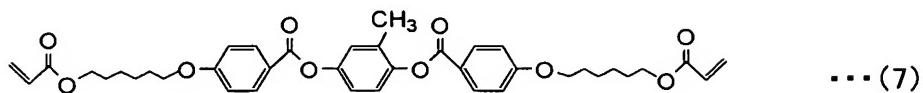
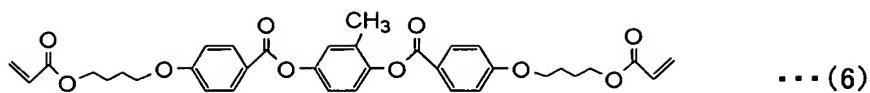
- 10 [0065] Substituted analogs of the aromatic hydrocarbon radicals represented by the formulae above may carry 1 to 4 substituents per aromatic ring, for example, or one or two substituents per aromatic ring or per group. The substituents may be identical or different. The substituents can be, for example, C₁-C₄-alkyl, nitro, halogen such as F, Cl, Br or I, phenyl or C₁-C₄-alkoxy.
- 15 [0066] Specific examples of the liquid crystal monomer can include monomers represented by the formulae (4) to (19) below.

[0067] [Chemical formulae 6-1]

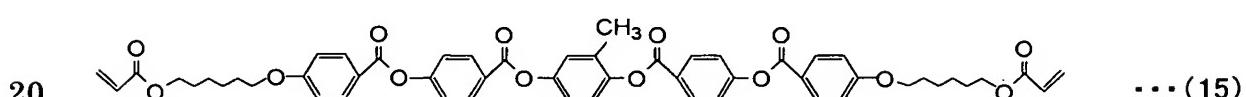
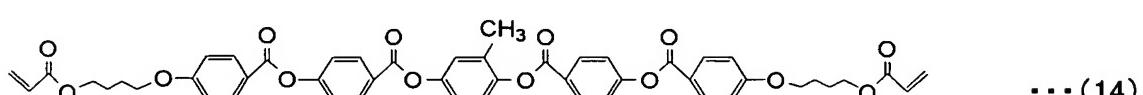
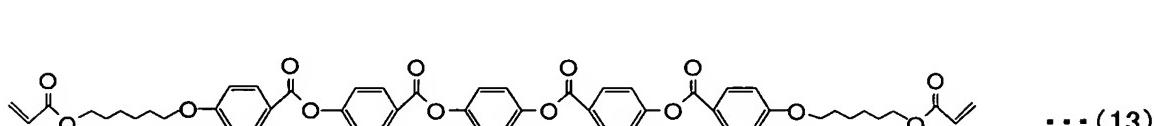
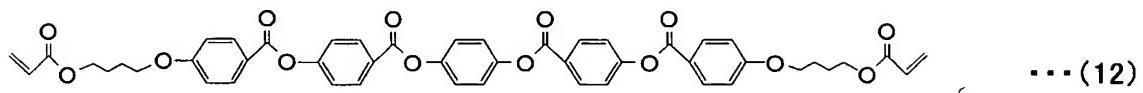


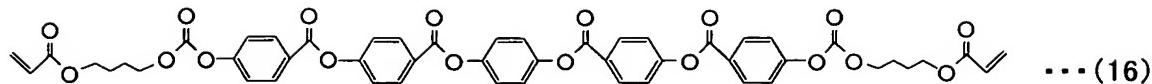
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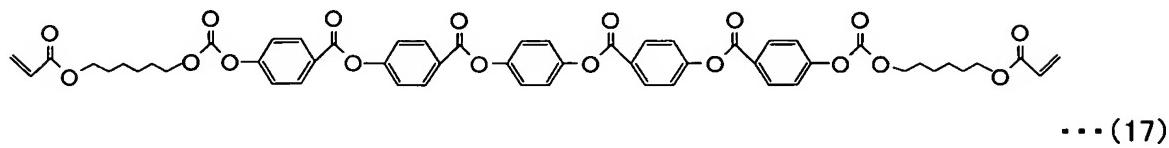


[Chemical formulae 6-2]

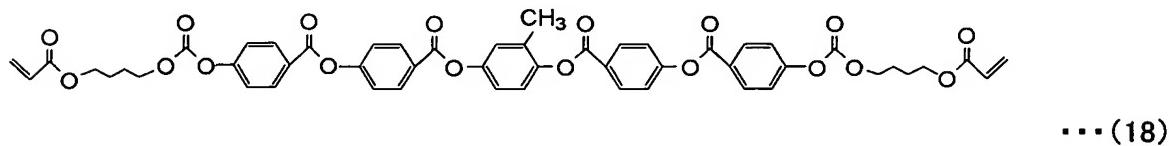




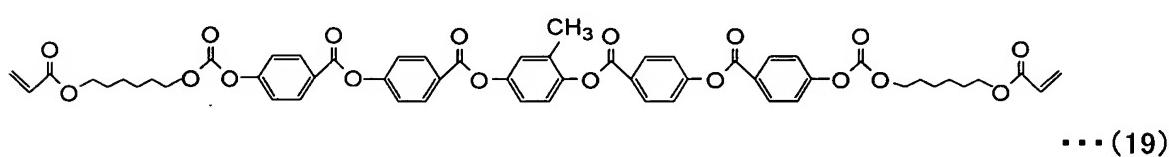
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... (17)



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[0068] The temperature range in which the liquid crystal monomer shows a liquid crystalline property varies depending on their kinds, but preferably ranges, for example, from 40°C to 120°C, more preferably ranges from 50°C to 100°C, and particularly preferably ranges from 60°C to 90°C.

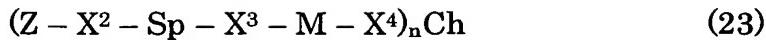
[0069] Although there is no particular limitation on the chiral dopant as long as it twists and aligns the liquid crystal monomer so as to have a cholesteric structure as described above, for example, a polymerizable chiral dopant is preferable. The above-described chiral dopants can be used.

These chiral dopants may be used alone or in combination of two or more.

[0070] More specifically, the polymerizable chiral dopant can be, for example, chiral compounds represented by the general formulae (20) to (23) below.

$$25 \quad (Z - X^5)_n Ch \quad (20)$$

$$(Z - X^2 - Sp - X^5)_n Ch \quad (21)$$

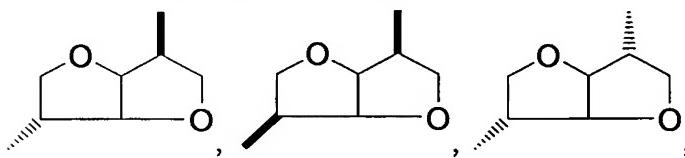


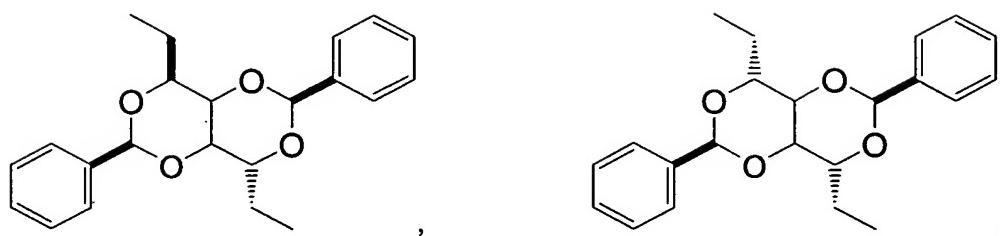
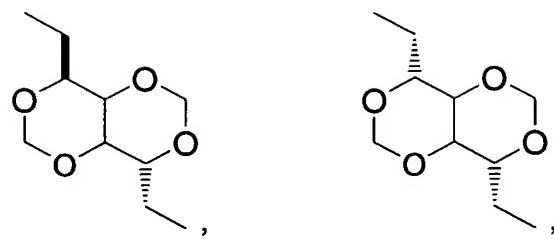
[0071] In the above formulae, Z is similar to that in the formula (2) above,

Sp is similar to that in the formula (2) above, X^2 , X^3 and X^4 are each,

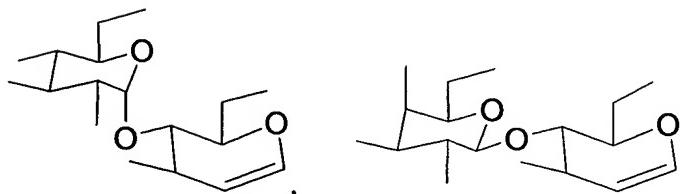
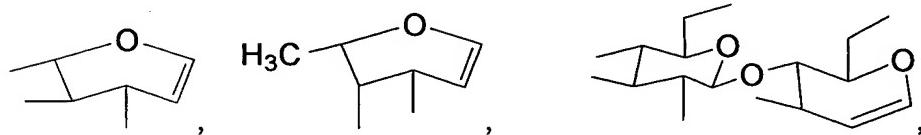
- 5 independently from one another, a chemical single bond, $-O-$, $-S-$, $-O-CO-$,
 $-CO-O-$, $-O-CO-O-$, $-CO-NR-$, $-NR-CO-$, $-O-CO-NR-$, $-NR-CO-O-$ or
 $-NR-CO-NR-$, and R is H or C_1-C_4 -alkyl. X^5 is a chemical single bond,
 $-O-$, $-S-$, $-O-CO-$, $-CO-O-$, $-O-CO-O-$, $-CO-NR-$, $-NR-CO-$,
 $-O-CO-NR-$, $-NR-CO-O-$, $-NR-CO-NR$, $-CH_2O-$, $-O-CH_2-$, $-CH=N-$,
10 $-N=CH-$ or $-N\equiv N-$. Similarly to the above, R is H or C_1-C_4 -alkyl.
- Similarly to the above, M is a mesogenic group. P^1 is hydrogen, a
 C_1-C_{30} -alkyl group, a C_1-C_{30} -acyl group or a C_3-C_8 -cycloalkyl group
substituted by 1 to 3 C_1-C_6 -alkyl, where n is an integer from 1 to 6. Ch is
an n-valent chiral group. In the formula (23) above, it is preferable that at
15 least one of X^3 and X^4 is $-O-CO-O-$, $-O-CO-NR-$, $-NR-CO-O-$ or
 $-NR-CO-NR-$. In the formula (22) above, when P^1 is an alkyl group, an
acyl group or a cycloalkyl group, for example, ether oxygen, thioether sulfur
or nonadjacent imino or C_1-C_4 -alkylimino groups may insert into its carbon
chain.
- 20 [0072] Examples of the above-noted chiral group of Ch include radicals
represented by the formulae below.

[0073] [Chemical formulae 7]



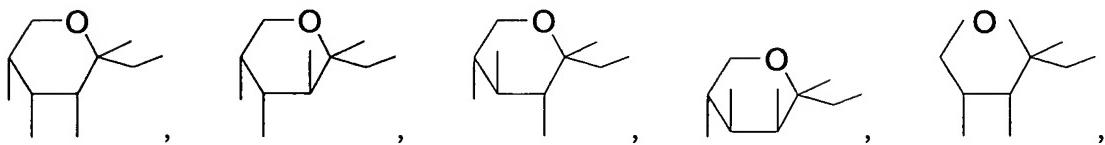


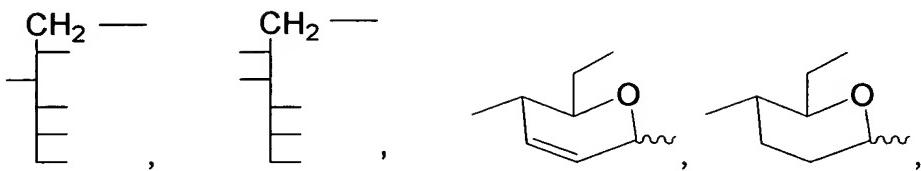
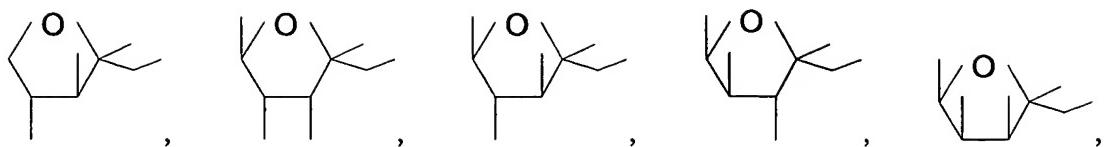
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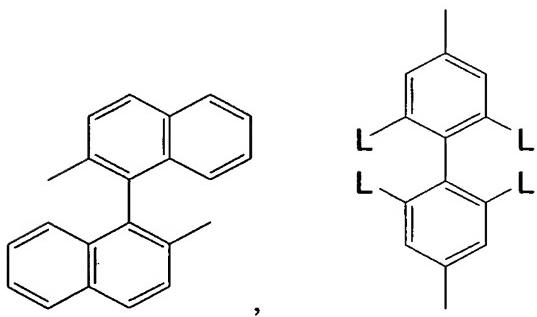
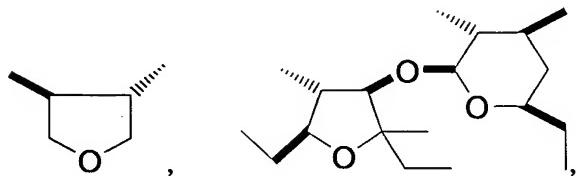
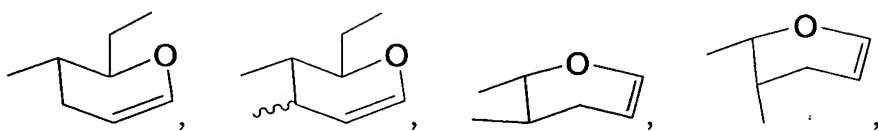
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[Chemical formulae 8]





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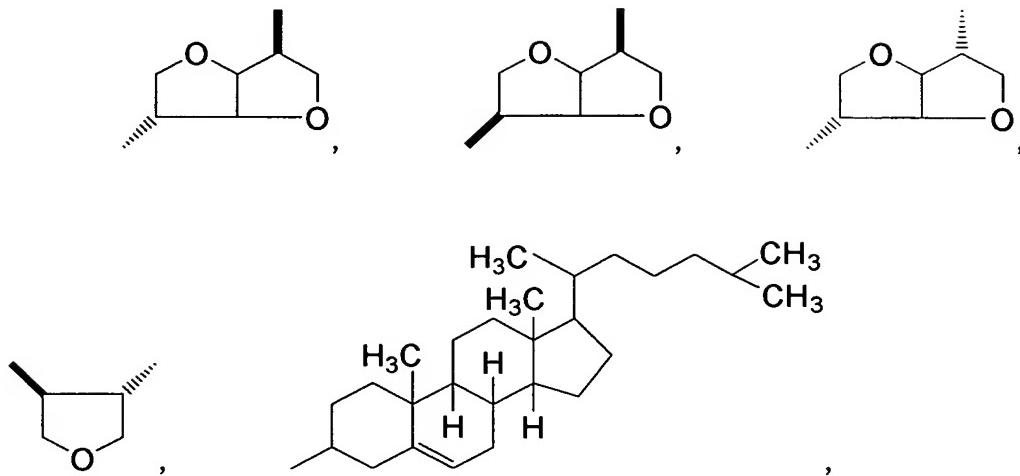


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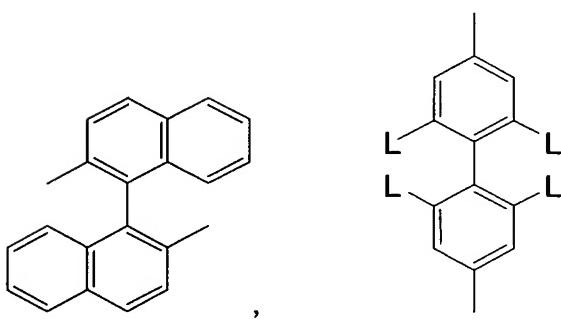
[0074] In the above radicals, L is C₁–C₄-alkyl, C₁–C₄-alkoxy, halogen, COOR, OCOR, CONHR or NHCOR, and R is C₁–C₄-alkyl. Terminal ends in the radicals represented by the formulae above indicate dangling bonds with the adjacent groups.

15 [0075] Among the above radicals, radicals represented by the formulae below are particularly preferable.

[0076] [Chemical formulae 9]



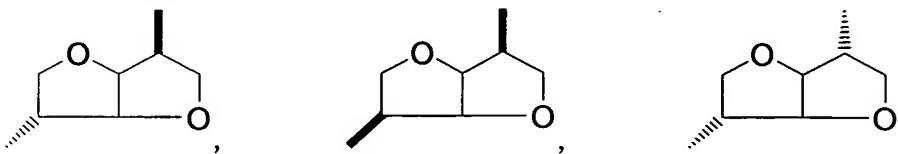
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[0077] It is preferable that the chiral compound represented by the formula (21) or (23) above is, for example, a radical in which n is 2, Z is H₂C=CH-

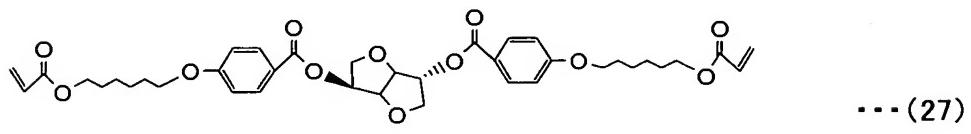
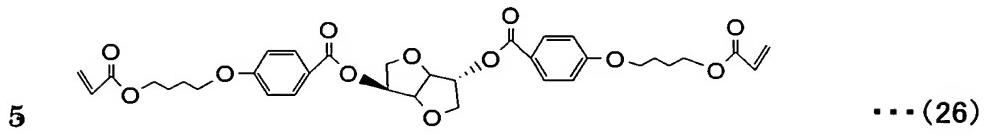
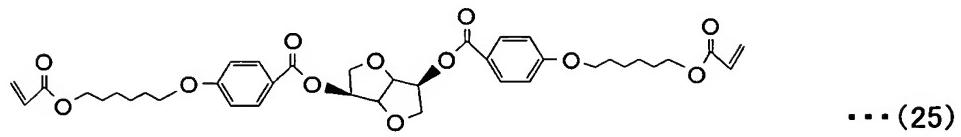
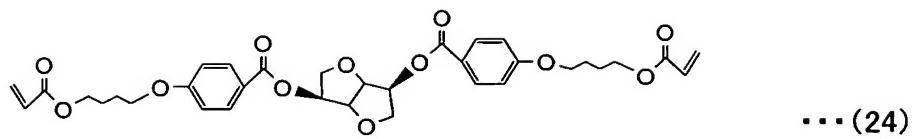
10 and Ch is represented by any of the formulae below.

[0078] [Chemical formulae 10]

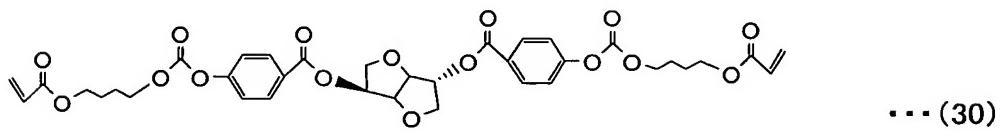
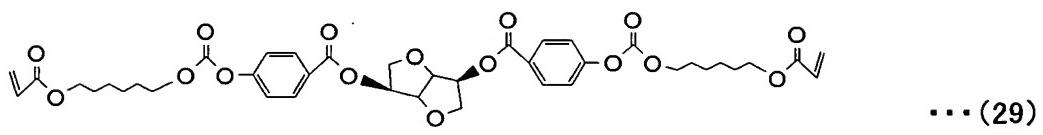


[0079] Specific examples of the chiral compound can include compounds
15 represented by the formulae (24) to (44) below. Incidentally, these chiral
compounds have a helical twisting power of $1 \times 10^{-6} \text{ nm}^{-1} \cdot (\text{wt}\%)^{-1}$ or more.

[0080] [Chemical formulae 11-1]

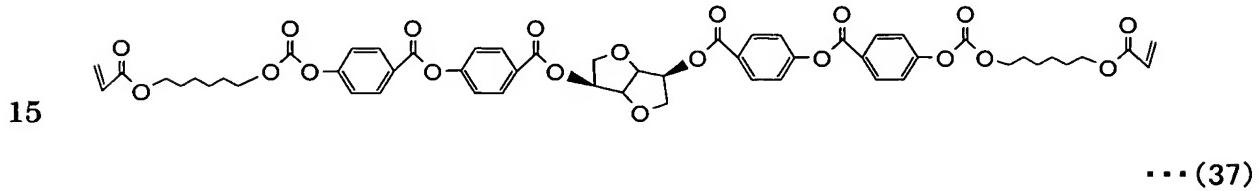
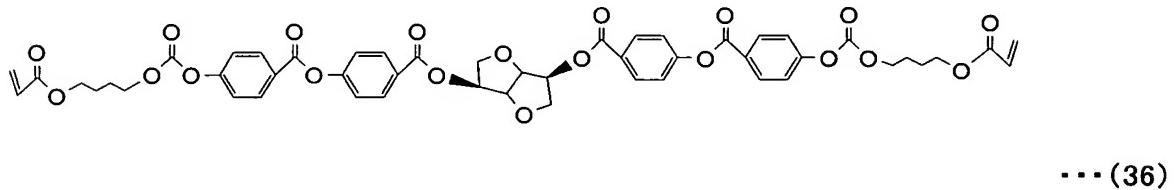
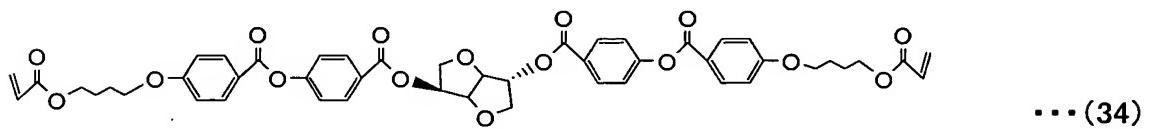
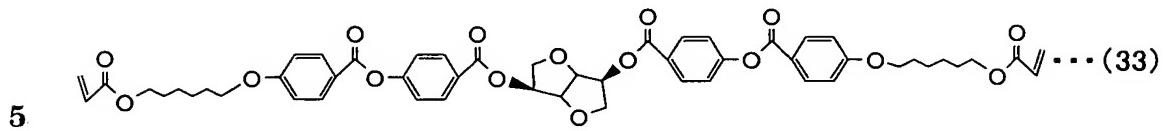
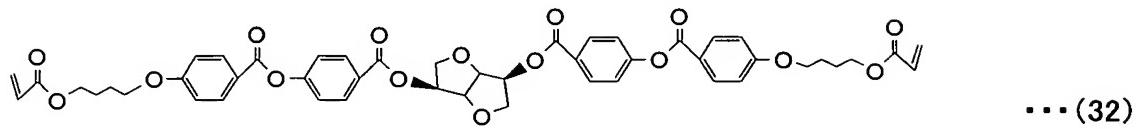
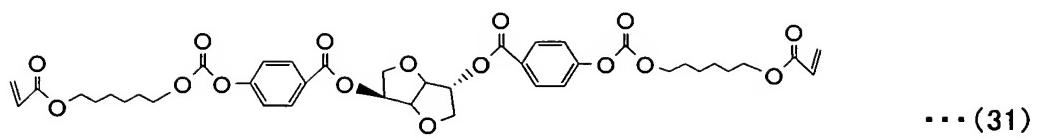


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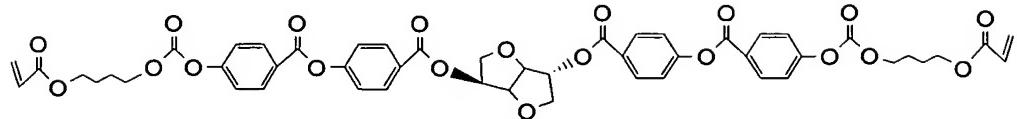


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[Chemical formulae 11-2]

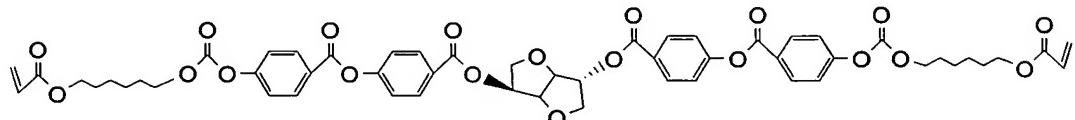


[Chemical formulae 11-3]



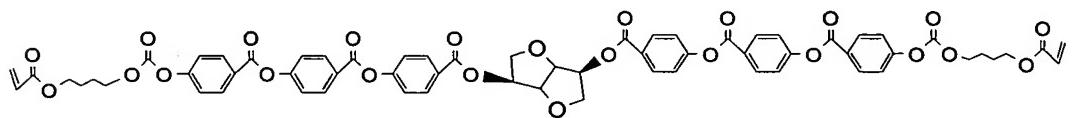
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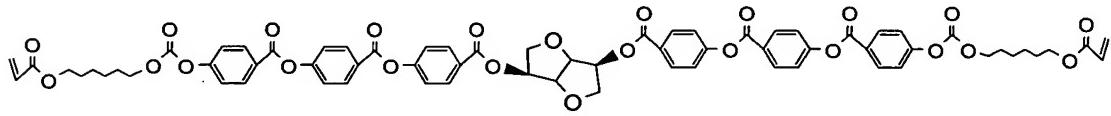


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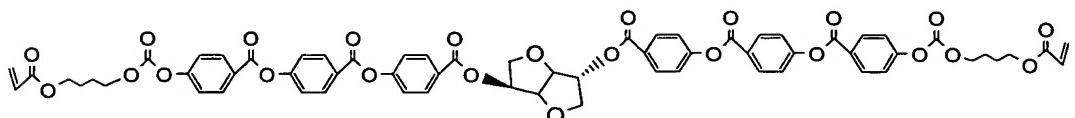


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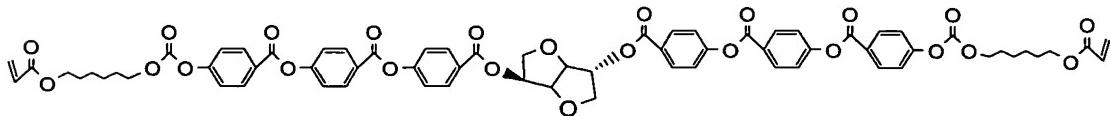
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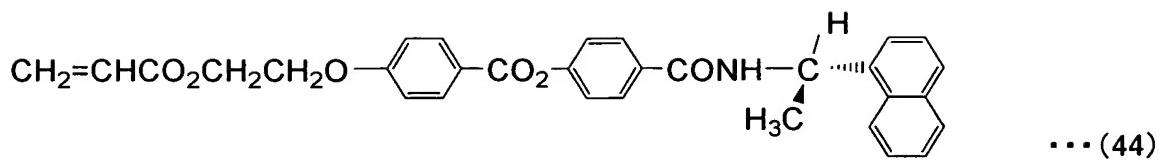


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... (43)



[0081] Other than the above-described chiral compounds, chiral compounds mentioned in, for example, DE-A 4342280; and German patent applications No. 19520660.6 and No. 19520704.1 can be used preferably.

[0082] The polymerizing agent and the cross-linking agent are not particularly limited but can be selected among the agents indicated below, for example. As the polymerizing agent, benzoyl peroxide (BPO), azobisisobutyronitrile (AIBN) or the like can be used, for example. As the cross-linking agent, an isocyanate-based cross-linking agent, an epoxy-based cross-linking agent, a metal chelate cross-linking agent or the like can be used, for example. These agents may be used alone or in combination of two or more.

[0083] The coating solution can be prepared by, for example, dissolving or dispersing the liquid crystal monomer or the like in a suitable solvent. The solvent is not particularly limited but can be, for example, halogenated hydrocarbons such as chloroform, dichloromethane, carbon tetrachloride, dichloroethane, tetrachloroethane, methylene chloride, trichloroethylene, tetrachloroethylene, chlorobenzene and orthodichlorobenzene; phenols such as phenol, p-chlorophenol, o-chlorophenol, m-cresol, o-cresol and p-cresol; aromatic hydrocarbons such as benzene, toluene, xylene, methoxybenzene and 1,2-dimethoxybenzene; ketone-based solvents such as acetone, methyl ethyl ketone (MEK), methyl isobutyl ketone, cyclohexanone, cyclopentanone, 2-pyrrolidone and N-methyl-2-pyrrolidone; ester-based solvents such as ethyl acetate and butyl acetate; alcohol-based solvents such as t-butyl alcohol, glycerin, ethylene glycol, triethylene glycol, ethylene glycol monomethyl ether, diethylene glycol dimethyl ether, propylene glycol, dipropylene glycol and 2-methyl-2,4-pentanediol; amide-based solvents such

as dimethylformamide and dimethylacetamide; nitrile-based solvents such as acetonitrile and butyronitrile; ether-based solvents such as diethyl ether, dibutyl ether, tetrahydrofuran and dioxane; or carbon disulfide, ethylcellosolve or butylcellosolve. In particular, toluene, xylene, mesitylene,

- 5 MEK, methyl isobutyl ketone, cyclohexanone, ethylcellosolve, butylcellosolve, ethyl acetate, butyl acetate, propyl acetate and ethylcellosolve acetate are preferable. These solvents may be used alone or as a mixture of two or more, for example.

[0084] The ratio of the chiral dopant to be added is determined suitably according to a desired helical pitch or a desired selective reflection wavelength range, for example. The added ratio with respect to the liquid crystal monomer ranges, for example, from 5 wt% to 23 wt%, and preferably ranges from 10 wt% to 20 wt%. As described above, by controlling the added ratio of the chiral dopant to the liquid crystal monomer in this manner, the selective wavelength range of an optical film to be formed can be set to the above-mentioned range. When the ratio of the chiral dopant to the liquid crystal monomer is 5 wt% or more, for example, it becomes significantly easy to control the selective reflection wavelength range of an optical film to be formed at a shorter wavelength side. On the other hand, 20 when this ratio is 23 wt% or less, the temperature range in which the liquid crystal monomer is aligned in the form of a cholesteric structure, that is, the temperature range in which the liquid crystal monomer is in a liquid crystalline phase becomes broad, so that a precise control of the temperature in a below-described aligning process is not necessary, which 25 makes the manufacturing significantly easier

[0085] For example, when chiral dopants with equal helical twisting powers are used, the selective reflection wavelength range to be formed is shifted further to the shorter wavelength side with an increase in the added ratio of the chiral dopant with respect to the liquid crystal monomer. Also, when 30 the added ratios of the chiral dopants with respect to the liquid crystal

monomer are equal, the selective reflection wavelength range of an optical film to be formed is shifted further to the shorter wavelength side with an increase in the helical twisting power of the chiral dopants. As a specific example, in the case where the selective reflection wavelength range of the

5 optical film to be formed is set to range from 200 to 220 nm, it is appropriate that the chiral dopant having a helical twisting power of 5×10^{-4} nm⁻¹.(wt%)⁻¹ be blended to be 11 wt% to 13 wt% with respect to the liquid crystal monomer, for example. In the case where the selective reflection wavelength range is set to range from 290 to 310 nm, it is appropriate that

10 the chiral dopant having a helical twisting power of 5×10^{-4} nm⁻¹.(wt%)⁻¹ be blended to be 7 wt% to 9 wt% with respect to the liquid crystal monomer, for example.

[0086] The combination of the liquid crystal monomer and the chiral dopant is not particularly limited, but specifically can be a combination of the

15 monomer of the formula (10) above and the chiral dopant of the formula (38) above, that of the monomer of the formula (11) above and the chiral dopant of the formula (39) above, or the like.

[0087] Further, the added ratio of the cross-linking agent or the polymerizing agent to the liquid crystal monomer ranges, for example, from

20 0.1 wt% to 10 wt%, preferably ranges from 0.5 wt% to 8 wt% and more preferably ranges from 1 wt% to 5 wt%. When the ratio of the cross-linking agent or the polymerizing agent to the liquid crystal monomer is 0.1 wt% or more, it becomes sufficiently easy to cure the cholesteric layer, for example. When this ratio is 10 wt% or less, the temperature range in

25 which the liquid crystal monomer is aligned in the form of a cholesteric structure, that is, the temperature range in which the liquid crystal monomer is in a liquid crystalline phase is sufficient, for example, so that the temperature can be controlled still more easily in the aligning process, which will be described later.

30 [0088] Moreover, for example, various additives may be blended suitably

into the coating solution as necessary. Examples of such additives include an antioxidant, a denaturant, a surfactant, a dye, a pigment, a discoloration preventing agent, a UV absorber and the like. These additives may be used alone or in combination of two or more, for example. More specifically,

5 conventionally known materials, for example, phenolic compounds, amine compounds, organic sulfur compounds or phosphinic compounds can be used as the antioxidant, and conventionally known materials, for example, glycols, silicones or alcohols can be used as the denaturant, for example.

10 Furthermore, the surfactant is added, for example, for smoothing the surface of the optical compensation layer and can be, for example, a silicone surfactant, an acrylic surfactant, a fluorochemical surfactant or the like.

In particular, a silicone surfactant is preferable.

[0089] When the liquid crystal monomer is used as mentioned above, the prepared coating solution has a viscosity with an excellent workability in application and expansion, for example. The viscosity of the coating solution usually varies depending on the concentration and temperature of the liquid crystal monomer. When the monomer concentration in the coating solution is in the above-described range of 5 wt% to 70 wt%, the viscosity ranges, for example, from 0.2 mPa·s to 20 mPa·s, preferably ranges 15 from 0.5 mPa·s to 15 mPa·s, and particularly preferably ranges from 1

20 mPa·s to 10 mPa·s. More specifically, when the monomer concentration of the coating solution is 30 wt%, the viscosity ranges, for example, from 2 mPa·s to 5 mPa·s, and preferably ranges from 3 mPa·s to 4 mPa·s. The coating solution viscosity of 0.2 mPa·s or more further prevents the coating solution from flowing undesirably during application, for example, whereas the viscosity of 20 mPa·s or less achieves a still better surface smoothness, further prevents thickness unevenness and allows easy application.

25 Incidentally, although the temperature range from 20°C to 30°C has been illustrated for the viscosity described above, there is no particular limitation 30 to this temperature.

[0090] Next, the coating solution is applied onto the alignment substrate, thus forming the expanded layer.

[0091] It is appropriate that the coating solution be flow-expanded by a conventionally known method such as roller coating, spin coating, wire bar

5 coating, dip coating, extrusion method, curtain coating or spray coating.

Among these methods, spin coating and extrusion coating are preferable considering the application efficiency.

[0092] The alignment substrate is not particularly limited as long as it can align the liquid crystal monomer. For example, a substrate obtained by

10 rubbing the surface of a plastic film or a plastic sheet of various kinds with a rayon cloth or the like can be used. The above-mentioned plastic is not particularly limited and can be, for example, triacetylcellulose (TAC), polyolefin such as polyethylene, polypropylene or poly(4-methyl pentene-1), polyimide, polyimide amide, polyetherimide, polyamide, polyether ether

15 ketone, polyether ketone, polyketone sulfide, polyethersulfone, polysulfone, polyphenylene sulfide, polyphenylene oxide, polyethylene terephthalate, polybutylene terephthalate, polyethylene naphthalate, polyacetal, polycarbonate, polyarylate, an acrylic resin, polyvinyl alcohol, polypropylene, cellulose-based plastics, an epoxy resin, a phenolic resin or the like.

20 Alternatively, the alignment substrate can be obtained by providing the above-mentioned plastic film or sheet on the surface of a substrate made of metal such as aluminum, copper or steel, a ceramic substrate or a glass substrate or by forming an obliquely deposited film of SiO₂ on that surface.

Also, it may be possible to use as the alignment substrate a laminate of the

25 above-mentioned plastic film or sheet and a birefringent stretched film that has been subjected to a stretching treatment such as uniaxial stretching to serve as an alignment film. Furthermore, it is preferable that the substrate itself has a birefringent property because the rubbing treatment and the lamination of the birefringent film on the surface described above

30 are not necessary. The substrate itself can be made birefringent property

as above by, for example, casting and extrusion forming other than the stretching treatment during the formation of the substrate.

[0093] Subsequently, the expanded layer is subjected to a heat treatment, thereby aligning the liquid crystal monomer in a liquid crystalline state.

- 5 Since the expanded layer contains the chiral dopant as well as the liquid crystal monomer, the liquid crystal monomer that is now in the liquid crystalline phase (the liquid crystalline state) is aligned while being given a twist by the chiral dopant. In other words, the liquid crystal monomer shows a cholesteric structure (a helical structure).
- 10 [0094] The temperature condition in the heat treatment can be determined suitably according to, for example, kinds of the liquid crystal monomer, more specifically, the temperature at which the liquid crystal monomer shows a liquid crystalline property. Usually, the temperature ranges from 40°C to 120°C, preferably ranges from 50°C to 100°C, and more preferably ranges
- 15 from 60°C to 90°C. A temperature of 40°C or more usually makes it possible to align the liquid crystal monomer sufficiently, whereas a temperature 120°C or less allows a wide range of selectable alignment bases of various kinds as described above, taking into account heat resistance, for example.
- 20 [0095] Next, the expanded layer in which the liquid crystal monomer is aligned is subjected to a cross-linking treatment or a polymerization treatment, thereby polymerizing or cross-linking the liquid crystal monomers and the chiral dopant. In this manner, the liquid crystal monomers are polymerized or cross-linked within itself or with the chiral dopant while maintaining the alignment in the form of the cholesteric structure, so that the alignment is fixed. Thus formed polymer is a non-liquid crystal polymer because the alignment has been fixed.
- 25 [0096] The polymerization treatment or the cross-linking treatment can be determined suitably depending on, for example, kinds of a polymerizing agent or a cross-linking agent to be used. For example, light irradiation is

appropriate in the case of using a photopolymerizing agent or a photocross-linking agent, and ultraviolet irradiation is appropriate in the case of using an ultraviolet polymerizing agent or an ultraviolet cross-linking agent.

- 5 [0097] According to the method described above, it is possible to provide, on the alignment substrate, an optical compensation layer formed of the non-liquid crystal polymer that is aligned in the form of a cholesteric structure. This optical compensation layer shows a non-liquid crystalline property because its alignment is fixed as described above. Therefore, it
10 does not transform, for example, between a liquid crystalline phase, a glassy phase and a crystalline phase according to changes in temperature, so that its alignment does not change with temperature. Consequently, it can be used for the optical compensation plate of the present invention as a high-performance retardation film that is not affected by temperature
15 change. Furthermore, when the selective reflection wavelength range is controlled to the above-noted range, light leakage and the like as described above can be suppressed.

- [0098] For example, the optical compensation layer can be peeled off from the alignment substrate and provided with an anti-cracking layer on at
20 least one surface thereof. Alternatively, for example, an anti-cracking layer can be formed on the surface of the optical compensation layer which is in a state being laminated on the alignment substrate.

- [0099] When the optical compensation layer is used as a laminate with the alignment substrate, it is preferable that the alignment substrate is a
25 transparent plastic film. The plastic film can be a film formed of, for example, cellulose such as TAC, polyolefin such as polyethylene, polypropylene or poly(4-methyl pentene-1), polyimide, polyamide imide, polyamide, polyetherimide, polyether ether ketone, polyketone sulfide, polyethersulfone, polysulfone, polyphenylene sulfide, polyphenylene oxide,
30 polyethylene terephthalate, polybutylene terephthalate, polyethylene

naphthalate, polyacetal, polycarbonate, polyarylate, an acrylic resin, polyvinyl alcohol, polypropylene, cellulose-based plastics, an epoxy resin, a phenolic resin, polynorbornene, polyester, polystyrene, polyvinyl chloride, polyvinylidene chloride, liquid crystal polymer or the like. These films may

5 be optically isotropic or anisotropic. Among these plastic films, films respectively formed of polypropylene, polyethylene terephthalate and polyethylene naphthalate are preferable, for example, considering a solvent resistance and a heat resistance. Furthermore, the polymer film described in JP 2001-343529 A (WO 01/37007) also can be used, for example. The

10 polymer material used can be a resin composition containing a thermoplastic resin whose side chain has a substituted or unsubstituted imido group and a thermoplastic resin whose side chain has a substituted or unsubstituted phenyl group and nitrile group, for example, a resin composition containing an alternating copolymer of isobutene and

15 N-methylmaleimide and an acrylonitrile-styrene copolymer. The polymer film may be formed by extruding the resin composition.

[0100] The above-mentioned transparent alignment substrate may be a single layer, for example, or a laminate of different polymers for improving a strength, a heat resistance and adhesion to the polymer and the liquid

20 crystal monomer, for example.

[0101] In addition, the transparent alignment substrate may generate no retardation owing to birefringence, or generate retardation owing to birefringence for the purpose of cancelling the polarization state of light reflected by a polarization separating layer, for example. Such cancelling of

25 the polarization state improves an efficiency of light utilization and allows the light to have the same polarization state as light from the light source, so that visual hue variation can be suppressed effectively. The transparent substrate generating the retardation owing to birefringence can be selected among, for example, stretched films of various polymers and may be a

30 substrate whose refractive index in the thickness direction is controlled.

This controlling can be carried out by, for example, making the polymer film adhere to a heat-shrinkable film and stretching them while heating.

[0102] The thickness of the plastic film usually ranges from 5 µm to 500 µm, preferably ranges from 10 µm to 200 µm, and more preferably ranges from 5 15 µm to 150 µm. The thickness of 5 µm or more provides a sufficient strength to the substrate, so that it is possible to prevent a problem of, for example, fracture during manufacturing or the like.

[0103] The optical compensation layer in the optical compensation plate of the present invention can include, as the constituent molecules, the above-noted non-liquid crystal polymers, but it can also include a liquid crystal polymer. In such a case, a cholesteric layer having liquid crystal polymers as constituent molecules can be formed by the method including the steps of, for example, forming an expanded layer by expanding onto an alignment base a coating solution that contains the above-mentioned liquid crystal polymer and the chiral dopant, and subjecting the expanded layer to a heat treatment so that the liquid crystal polymer can be aligned in the form of a cholesteric structure.

[0104] The polarizing plate of the present invention includes, as mentioned above, a polarizer, a transparent protective layer and the optical compensation plate of the present invention, and the polarizer and the optical compensation plate are laminated together via the transparent protective layer.

[0105] The configuration of the polarizing plate of the present invention is not particularly limited as long as the anti-cracking layer that is formed of 25 an adhesive that contains a moisture-curing isocyanate compound and has a glass transition temperature of 100°C or less is laminated on at least one surface of the optical compensation layer. Specific examples are described below.

[0106] An example thereof is a configuration in which the optical 30 compensation plate and the transparent protective layer are directly

adhered to each other by the anti-cracking layer of the optical compensation plate. Such a polarizing plate can be formed by, for example, when manufacturing the optical compensation plate, applying the curable adhesive agent onto the surface of the optical compensation layer, then 5 disposing further the laminate of the transparent protective film and the polarizer onto the coating film (the anti-cracking layer) of the curable adhesive agent so as to allow the laminate and the coating film to be in contact with each other, and subsequently curing the coating film.

According to this structure, the anti-cracking layer serves to prevent cracks 10 in the optical compensation layer, and also can function to adhere the laminate of the polarizer and the transparent protective layer with the optical compensation layer, thus providing the polarizing plate which is excellent in terms of strength and thickness. Here, it is preferable that the laminate of the transparent protective layer and the polarizer is disposed so 15 that the transparent protective layer may be in contact with the coating film of the curable adhesive agent, and that the transparent protective layer and the anti-cracking layer are adhered directly to each other.

[0107] The transparent protective layer may be laminated only on one 20 surface of the polarizer or both surfaces thereof. In the case of laminating the transparent protective layer on both surfaces, the kinds of transparent protective layers to be used may be, for example, the same or different.

[0108] Here, the anti-cracking layer can be laminated on one surface of the optical compensation layer or both surfaces thereof.

[0109] When the anti-cracking layer is laminated on only one surface of the 25 optical compensation layer as mentioned above, the optical compensation plate preferably has a configuration in which, for example, a pressure-sensitive adhesive layer is additionally laminated on the surface of the optical compensation layer opposed to the surface on which the anti-cracking layer is laminated. Moreover, the anti-cracking layer which 30 is laminated on the surface of the optical compensation layer and the

polarizer are preferably laminated together via the transparent protective layer. According to this configuration, cracks in the optical compensation layer can be prevented by the anti-cracking layer, and it can be bonded with, for example, a liquid crystal cell, and any other optical member or the like 5 easily as necessary. Since the pressure-sensitive adhesive layer can be thin, the thickness of the polarizing plate of the present invention also can be reduced.

[0110] The thickness of the pressure-sensitive adhesive layer is not particularly limited, but it ranges, for example, from 5 µm to 50 µm, more 10 preferably ranges from 10 µm to 40 µm, and particularly preferably ranges from 15 µm to 35 µm.

[0111] Though the material of the pressure-sensitive adhesive layer is not particularly limited as long as it has a sticking property, conventionally known pressure-sensitive adhesives, such as an acrylic resin-based 15 pressure-sensitive adhesive, a rubber-based pressure-sensitive adhesive and a vinyl-based pressure-sensitive adhesive, can be used.

[0112] The pressure-sensitive adhesive layer can be formed on the surface of the optical compensation layer by, for example, a method of applying a solution or melt of various materials directly onto the surface of the 20 polarizing plate by an expanding method such as flow-expanding and coating. Alternatively, a pressure-sensitive adhesive layer is formed on a liner (a mold-releasing film), which will be described later, in the same manner and transferred to the surface of the optical compensation layer.

[0113] In the case of laminating the pressure-sensitive adhesive layer on 25 the other surface of the optical compensation layer as mentioned above, it is preferable to dispose a liner on the surface of the pressure-sensitive adhesive layer so as to cover the surface, for the purpose of, for example, preventing contamination of the exposed surface of the pressure-sensitive adhesive layer, and maintaining the sticking property until the adhesive 30 layer is put to use, i.e., for example, until the pressure-sensitive adhesive is

bonded to another member. The liner can be made of a suitable film such as the below-mentioned transparent protective film, by applying a peeling coat of a peeling agent if required, and the peeling agent may be selected, for example, from a silicone-based agent, a long-chain alkyl-based agent, a

5 fluorine-based agent, an agent comprising molybdenum sulfide or the like.

Since this liner is peeled off before the use of the polarizing plate of the present invention, the thickness thereof is not particularly limited but may be the same as that of a conventionally known liner.

[0114] Whereas, in the case where the anti-cracking layers are formed on 10 both surfaces of the optical compensation layer, one of the anti-cracking layers in the optical compensation plate and the polarizer are preferably laminated together via the transparent protective layer. Moreover, it is preferable in the optical compensation plate that the pressure-sensitive adhesive layer and the liner are further disposed in this order on the surface 15 of the anti-cracking layer on which the polarizer is not laminated via the transparent protective layer. By laminating the anti-cracking layers on both surfaces of the optical compensation layer in this manner, the strength of the optical compensation plate further can be improved, and the pressure-sensitive adhesive layer can be attached easily to another member.

[0115] In the polarizing plate of the present invention, the polarizer is not 20 particularly limited but a conventionally known polarizing film can be used. Specific examples include a film prepared by a conventionally known method of, for example, dyeing by allowing a film of various kinds to adsorb 25 a dichroic material such as iodine or a dichroic dye, followed by cross-linking, stretching and drying. Especially, films that transmit linearly polarized light when natural light is made to enter those films are preferable, and films having excellent light transmittance and polarization degree are preferable. Examples of the film of various kinds in which the dichroic material is to be adsorbed include hydrophilic polymer films such as 30 PVA-based films, partially-formalized PVA-based films,

partially-saponified films based on ethylene-vinyl acetate copolymer and cellulose-based films. Other than the above, polyene aligned films such as dehydrated PVA and dehydrochlorinated polyvinyl chloride can be used, for example. Among them, the PVA-based film is preferable. In addition, the thickness of the polarizing film generally ranges from 1 µm to 80 µm, though it is not limited to this.

- 5 [0116] The transparent protective layer is not particularly limited but can be a conventionally known transparent film. For example, transparent protective films having excellent transparency, mechanical strength, thermal stability, moisture-shielding property and isotropism are preferable.
- 10 Specific examples of materials for such a transparent protective layer can include cellulose-based resins such as triacetylcellulose, and transparent resins based on polyester, polycarbonate, polyamide, polyimide, polyethersulfone, polysulfone, polystyrene, polynorbornene, polyolefin, acrylic substances, acetate and the like. Thermosetting resins or ultraviolet-curing resins based on the acrylic substances, urethane, acrylic urethane, epoxy, silicones and the like can be used as well. Among them, a TAC film having a surface saponified with alkali or the like is preferable in view of the polarization property and durability.
- 15 [0117] Moreover, the polymer film described in JP 2001-343529 A (WO 01/37007) also can be used. The polymer material used can be a resin composition containing a thermoplastic resin whose side chain has a substituted or unsubstituted imido group and a thermoplastic resin whose side chain has a substituted or unsubstituted phenyl group and nitrile group,
- 20 for example, a resin composition containing an alternating copolymer of isobutene and N-methylmaleimide and an acrylonitrile-styrene copolymer. Alternatively, the polymer film may be formed by extruding the resin composition.
- 25 [0118] It is preferable that the transparent protective layer is colorless.
- 30 More specifically, a retardation value (Rth) of the film in its thickness

direction as represented by the equation below preferably ranges from -90 nm to +75 nm, more preferably ranges from -80 nm to +60 nm, and particularly preferably ranges from -70 nm to +45 nm. When the retardation value is within the range of -90 nm to +75 nm, coloration

- 5 (optical coloration) of the polarizing plate, which is caused by the protective film, can be solved sufficiently. In the equation below, n_x , n_y , n_z indicate refractive indices respectively in an X-axis direction, a Y-axis direction and a Z-axis direction of the transparent protective layer. Here, the X-axis direction is an axial direction exhibiting a maximum refractive index within
10 the plane, the Y-axis direction is an axial direction perpendicular to the X axis within the plane, and the Z-axis direction is a thickness direction perpendicular to the X axis and the Y axis. The letter d denotes the thickness of the transparent protective layer.

$$R_{th} = [\{ (n_x + n_y) / 2 \} - n_z] \cdot d$$

- 15 [0119] The transparent protective layer further may have an optically compensating function. As such a transparent protective layer having the optically compensating function, it is possible to use, for example, a known layer used for preventing coloration caused by changes in a visible angle based on retardation in a liquid crystal cell or for widening a preferable
20 viewing angle. Specific examples include various films obtained by stretching the above-described transparent resins uniaxially or biaxially, an alignment film of a liquid crystal polymer or the like, and a laminate obtained by providing an alignment layer of a liquid crystal polymer or the like on a transparent base. Among the above, the alignment film of a
25 liquid crystal polymer is preferable because a wide viewing angle with excellent visibility can be achieved. Particularly preferable is an optically compensating retardation plate obtained by supporting an optically compensating layer with the above-mentioned triacetylcellulose film or the like, where the optically compensating layer is made of an incline-aligned
30 layer of a discotic or nematic liquid crystal polymer. This optically

compensating retardation plate can be a commercially available product, for example, "WV film" manufactured by Fuji Photo Film Co., Ltd.

Alternatively, the optically compensating retardation plate can be prepared by laminating two or more layers of the retardation film and the film

- 5 support of triacetylcellulose film or the like so as to control the optical characteristics such as retardation.

[0120] The thickness of the transparent protective layer is not particularly limited but can be determined suitably according to retardation or protection strength, for example. In general, the thickness is 5 mm or less, 10 preferably is 1 mm or less, more preferably ranges from 1 μm to 500 μm , and particularly preferably ranges from 5 to 150 μm .

[0121] The transparent protective layer can be formed suitably by a conventionally known method such as a method of coating the polarizing film with the above-mentioned various transparent resins or a method of 15 laminating the transparent resin film, the optically compensating retardation plate or the like on the polarizing film, or can be a commercially available product.

[0122] The transparent protective layer further may be subjected to, for example, a hard coating treatment, an antireflection treatment, treatments 20 for anti-sticking, diffusion and anti-glaring and the like. The hard coating treatment aims at preventing scratches on the surfaces of the polarizing plate, and is a treatment of, for example, providing a hardened coating film that is formed of a curable resin and has excellent hardness and smoothness onto a surface of the transparent protective layer. The curable resin can be, 25 for example, ultraviolet-curing resins of silicone base, urethane base, acrylic substance base, and epoxy base. The treatment can be carried out by a conventionally known method. The anti-sticking treatment aims at preventing adjacent layers from sticking to each other. The antireflection treatment aims at preventing reflection of external light on the surface of 30 the polarizing plate, and can be carried out by forming a conventionally

known antireflection layer or the like.

[0123] The anti-glare treatment aims at preventing reflection of external light on the polarizing plate surface from hindering visibility of light transmitted through the polarizing plate. The anti-glare treatment can be carried out, for example, by providing microscopic asperities on a surface of the transparent protective layer by a conventionally known method. Such microscopic asperities can be provided, for example, by roughening the surface by sand-blasting or embossing, or by blending transparent fine particles in the above-described transparent resin when forming the transparent protective layer.

[0124] The transparent fine particles may be silica, alumina, titania, zirconia, stannic oxide, indium oxide, cadmium oxide, antimony oxide or the like. Other than the above, inorganic fine particles having an electrical conductivity or organic fine particles comprising, for example, crosslinked or uncrosslinked polymer particles can be used as well. The average particle diameter of the transparent fine particles ranges, for example, from 0.5 µm to 20 µm, though there is no specific limitation. In general, a blend ratio of the transparent fine particles preferably ranges from 2 to 70 parts by weight, and more preferably ranges from 5 to 50 parts by weight with respect to 100 parts by weight of the above-described transparent resin, though there is no specific limitation.

[0125] An anti-glare layer in which the transparent fine particles are blended can be used as the transparent protective layer itself or provided as a coating layer applied onto the transparent protective layer surface. Furthermore, the anti-glare layer also can function as a diffusion layer to diffuse light transmitted through the polarizing plate in order to widen the viewing angle (i.e., visually-compensating function).

[0126] The antireflection layer, the anti-sticking layer, the diffusion layer and the anti-glare layer mentioned above can be laminated on the polarizing plate, as a sheet of optical layers comprising these layers,

separately from the transparent protective layer.

[0127] In the polarizing plate of the present invention, the method for laminating the polarizer and the transparent protective layer on each other is not particularly limited but can be a conventionally known method. In

5 general, a pressure-sensitive adhesive, an adhesive or the like can be used. The kinds thereof can be determined suitably depending on materials of the polarizer and the transparent protective layer. The adhesive is not particularly limited but can be, for example, a polymer adhesive based on an acrylic substance, vinyl alcohol, silicone, polyester, polyurethane, polyether 10 or the like, or a rubber-based adhesive. Among these materials, materials having excellent moisture absorption and heat resistance are preferable, for example. If the material has such characteristics, when the polarizing plate of the present invention is used in a liquid crystal display, for example, it is possible to provide a high-quality durable display apparatus that can 15 prevent foaming or peeling caused by moisture absorption, degradation in the optical properties and warping of a liquid crystal cell caused by difference in thermal expansion coefficients and the like.

[0128] Also, the pressure-sensitive adhesive, the adhesive or the like described above do not peel off easily even when being exposed to moisture 20 or heat, for example, and have excellent light transmittance and polarization degree. More specifically, polyvinyl alcohol-based adhesives are preferable when the polarizer is a polyvinyl alcohol-based film, in light

of stability of adhering treatment. These adhesive and pressure-sensitive adhesive may be applied directly onto surfaces of the polarizer and the 25 transparent protective layer, or a layer of a tape or the like formed of the adhesive or pressure-sensitive adhesive may be disposed on the surfaces thereof. Further, when these adhesives and the pressure-sensitive adhesive are prepared as an aqueous solution, for example, other additives or a catalyst such as an acid catalyst may be blended as necessary.

30 [0129] The pressure-sensitive adhesive layer can be a monolayer or a

laminate. The laminate can include monolayers different from each other in type or in composition. When arranged on both surfaces of the polarizer, the pressure-sensitive adhesive layers can be the same or can be different from each other in types or compositions.

- 5 [0130] The thickness of the pressure-sensitive adhesive layer can be determined suitably depending on the constituents or the like of the polarizing plate. In general, it ranges from 1 μm to 500 μm .
- [0131] Adhesiveness of the pressure-sensitive adhesive layer can be controlled suitably by a conventionally known method. For example, the 10 degree of cross-linkage and the molecular weight will be adjusted on the basis of a composition or a molecular weight of the base polymer for forming the pressure-sensitive adhesive layer, a cross-linking method, a content ratio of the crosslinkable functional group, and a ratio of the blended cross-linking agent.
- 15 [0132] The optical compensation plate and the polarizing plate of the present invention may be treated with an UV absorber such as salicylate ester compounds, benzophenone compounds, benzotriazole compounds, cyanoacrylate compounds or nickel complex salt-based compounds so as to provide an UV absorbing capability.
- 20 [0133] The polarizing plate of the present invention is not limited to the above-mentioned configurations, but further can include various optical members, such as a retardation film, a liquid crystal film, a light scattering film, or a diffraction film having other refractive index structures.
- [0134] The polarizing plate of the present invention can be used in various 25 display apparatus such as a liquid crystal display as described above. The liquid crystal display can be formed by a conventionally known method. That is, the liquid crystal display generally is formed by assembling suitably constituent parts including optical elements such as a liquid crystal cell and a polarizing plate and, as necessary, an illuminating system, and
- 30 incorporating a driving circuit. The formation of the liquid crystal display

of the present invention has no particular limitation as long as the polarizing plate of the present invention is used. The liquid crystal cell can be a cell of any types, for example, a TN type, an STN type or a π type.

[0135] More specific examples include a liquid crystal display in which the

5 polarizing plate of the present invention is arranged on one side or both sides of a liquid crystal cell. Especially, in the case where the polarizing plate of the present invention includes the pressure-sensitive adhesive layer and the liner as mentioned above, the polarizing plate can be disposed by peeling off the liner and attaching the thus exposed pressure-sensitive

10 adhesive layer to the liquid crystal cell. When disposing the polarizing

plate to the liquid crystal cell, in the case where the retardation plate and the polarizing plate are disposed on both sides of the liquid crystal cell, the retardation plates or the polarizing plates can be the same or different.

Moreover, for forming a liquid crystal display, one layer or two or more

15 layers of suitable parts such as a diffusion plate, an anti-glare layer, an antireflection layer, a protective plate, a prism array sheet, a lens array sheet, an optical diffuser, a backlight, a reflective plate, a semitransparent reflective plate and a brightness enhancement plate can be arranged at suitable positions.

20 [0136] Next, the polarizing plate of the present invention can be used also for an organic EL apparatus, in the same manner as the above-described liquid crystal display.

[0137] In general, an organic EL apparatus has a luminant (an organic EL luminant) that is prepared by laminating a transparent electrode, an

25 organic luminant layer and a metal electrode in a certain order on a transparent substrate. Here, the organic luminant layer is a laminate of various organic thin films. Known examples thereof include: a laminate of a hole injection layer made of a triphenylamine derivative or the like and a luminant layer made of a phosphorous organic solid such as anthracene; a

30 laminate of the luminant layer and an electron injection layer made of a

perylene derivative or the like; or a laminate of the hole injection layer, the luminant layer and the electron injection layer.

[0138] In general, the organic EL apparatus emits light on the following principle: a voltage is applied to the transparent electrode and the metal

5 electrode so as to inject holes and electrons into the organic luminant layer, energy generated by the re-bonding of these holes and electrons excites the phosphor, and the excited phosphor emits light when it returns to the basis state. The mechanism of the re-bonding during the process is similar to that of an ordinary diode. This implies that a current and the light

10 emitting intensity exhibit a considerable nonlinearity accompanied with a rectification with respect to the applied voltage.

[0139] It is preferred for the organic EL apparatus that at least one of the electrodes is transparent so as to obtain luminescence at the organic luminant layer. In general, a transparent electrode of a transparent

15 conductive material such as indium tin oxide (ITO) is used for the anode. Use of substances having small work function for the cathode is effective for facilitating the electron injection and thereby raising luminous efficiency, and in general, metal electrodes such as Mg–Ag and Al–Li can be used.

[0140] In an organic EL apparatus configured as described above, the
20 organic luminant layer usually is made of a film that is extremely thin such as about 10 nm. Therefore, the organic luminant layer can transmit substantially as much light as the transparent electrode does. As a result, when the layer does not illuminate, a light beam entering from the surface of the transparent substrate and passing through the transparent electrode and the organic luminant layer before being reflected at the metal electrode comes out again to the surface of the transparent substrate. Thereby, the display surface of the organic EL apparatus looks like a mirror when viewed from the outside.

[0141] A transparent electrode can be provided on the surface of the organic
30 luminant layer that emits light by application of a voltage. At the same

time, in an organic EL apparatus including an organic EL luminant having a metal electrode on the back surface of the organic luminant layer, for example, a polarizing plate can be provided on the surface of the transparent electrode and a retardation plate can be provided between the

5 transparent electrode and the polarizing plate. As this polarizing plate, the polarizing plate according to the present invention can be applied.

[0142] The retardation plate and the polarizing plate function to polarize light which enters from outside and is reflected by the metal electrode, and thus the polarization has an effect that the mirror of the metal electrode

10 cannot be viewed from exterior. Particularly, the mirror of the metal

electrode can be shaded completely by forming the retardation plate with a quarter wavelength plate and adjusting an angle formed by the polarizing plate and the polarization directions of the retardation plate to be $\pi/4$.

[0143] That is, the polarizing plate transmits only the linearly polarized

15 light component among the external light entering the organic EL apparatus. In general, the linearly polarized light is changed into

elliptically polarized light by the retardation plate. When the retardation plate is a quarter wavelength plate and when the angle of the polarization directions of the polarizing plate and the retardation plate is $\pi/4$, the light is

20 changed into circularly polarized light.

[0144] Generally, this circularly polarized light passes through the

transparent substrate, the transparent electrode, and the organic thin film.

After being reflected by the metal electrode, the light passes again through the organic thin film, the transparent electrode and the transparent

25 substrate, and turns into linearly polarized light at the retardation plate.

Moreover, since the linearly polarized light crosses the polarization direction of the polarizing plate at a right angle, it cannot pass through the polarizing plate. As a result, the mirror of the metal electrode can be shaded completely.

30 [0145] The polarizer of the present invention is not limited to the

application in the liquid crystal display and the EL apparatus mentioned above, but can be applied also to, for example, various self-light-emitting image displays such as a plasma display, a FED display and the like.

(Example 1)

- 5 [0146] Next, the present invention will be further described using Examples and Comparative examples mentioned below. However, the present invention is not limited to these Examples.

[0147] Method for measuring a glass transition temperature

An adhesive was poured into a frame (25 mm × 80 mm × 2 mm) that 10 was formed of tetrafluoroethylene, and was left at room temperatures for 24 hours so as to be cured, whereby a film with a thickness of 200 µm was obtained. A part of this film with no air bubble trapped therein was cut into a size of 25 mm × 5 mm × 200 µm so as to make a sample. Then, viscoelasticity of the sample was measured at temperatures ranging from 15 -30°C to 200°C, by using a visco-elastometer ARES manufactured by TA INSTRUMENTS JAPAN. Assuming that a result of the measurement is represented by $\tan \delta$, a temperature that provides a maximal value of $\tan \delta$ is represented by a glass transition temperature (T_g). The $\tan \delta$ is a ratio between a storage shear modulus (G') and a loss shear modulus (G''), and 20 can be represented by the following equation.

$$\tan \delta = G'' / G'$$

[0148] Method for measuring microhardness

The microhardness was calculated from an indentation deepness and an indentation load that were measured by using a thin film hardness 25 meter (trade name: MH4000, MHA-400 or the like) manufactured by NEC Corporation with an indentation speed of 0.5 nm/sec and a maximum indentation load of 1 g.

[0149] 1 wt % aqueous solution of polyvinyl alcohol (PVA) (manufactured by The Nippon Synthetic Chemical Industry Co., Ltd.; trade name: NH-18) 30 was applied onto a triacetyl cellulose (TAC) film (manufactured by Fuji

Photo Film Co., Ltd.; trade name: T-50SH) with a film thickness of 50 μm , and was dried at 90°C, thereby forming a PVA film with a film thickness of approximately 0.01 μm or less. Subsequently, the surface of this film was rubbed so as to obtain an alignment film. The liquid crystal monomer (a polymerizable rod-like nematic crystal) represented by the above formula (6) and the chiral dopant represented by the above formula (44) were mixed in a weight ratio of 7 : 3, respectively, and this mixture was dissolved into toluene so as to obtain a solution of 30 wt%. Moreover, a photopolymerization initiator (trade name: IRGACURE; manufactured by Ciba Specialty Chemicals) was added to the toluene solution so as to prepare a coating solution. Here, a blend ratio of the photopolymerization initiator was 1.5 parts by weight with respect to 100 parts by weight of the toluene solution. Next, the coating solution was applied onto the alignment film, which was subsequently treated by heat at 90°C for 1 minute, thereby aligning the liquid crystal monomer. Furthermore, the liquid crystal monomers were polymerized by UV irradiation so as to fix the alignment. Subsequently, the TAC film and the PVA film were removed, thereby obtaining an optical compensation layer with a thickness of 5 μm . In-plane retardation of this optical compensation layer was 1 nm, and retardation thereof in the thickness direction was 200 nm.

[0150] The thus obtained optical compensation layer and a commercially available polarizing plate (manufactured by Nitto Denko Corporation; trade name: SEG5224DU, used also in the following examples) were adhered to each other by roller, using an adhesive containing a moisture-curing isocyanate compound (manufactured by MITSUI TAKEDA CHEMICALS INC; trade name: M-631N) with T_g of 50°C. The adhesive was cured by drying at 50°C for 24 hours. The thickness of the anti-cracking layer formed by curing the adhesive was 5 μm , and the microhardness thereof was 0.3 GPa.

30 Next, a liner (a mold-releasing film, manufactured by Mitsubishi

Polyester Film Corporation; trade name: MRF38) was adhered by roller onto a surface of the optical compensation layer opposed to the surface to which the polarizing plate was adhered, using an acrylic pressure-sensitive adhesive (thickness: 20 µm). Thereby, a polarizing plate with an optical compensation layer was manufactured.

5 (Example 2)

[0151] An polarizing plate with an optical compensation layer was manufactured in the same manner as Example 1 except laminating the polarizing plate and the liner, using an adhesive containing a moisture-curing isocyanate compound (manufactured by MITSUI TAKEDA CHEMICALS INC; trade name: M-605N) with Tg of 90°C. The thickness of the anti-cracking layer formed of the adhesive was 5 µm, and the microhardness thereof was 0.35 GPa.

10 (Comparative example 1)

15 [0152] The adhesive containing the moisture-curing isocyanate compound (manufactured by MITSUI TAKEDA CHEMICALS INC; trade name: M-605N) with Tg of 90°C, which was used in Example 2 mentioned above, and a copolymer A were mixed in a weight ratio of 9 : 1, respectively, thereby preparing an adhesive that contains the moisture-curing isocyanate 20 compound and has Tg of 120°C. Here, the copolymer A was a polymer with a molecular weight of 2,000,000, which was obtained by polymerizing butylacrylate and acrylic acid in a weight ratio of 100 : 5, respectively.

An polarizing plate with an optical compensation layer was manufactured in the same manner as Example 1 except laminating the 25 polarizing plate and the liner, using the adhesive containing the moisture-curing isocyanate compound. The thickness of the anti-cracking layer formed of the adhesive was 5 µm, and the microhardness thereof was 0.35 GPa.

[0153] The liner was peeled off from the polarizing plate with the optical 30 compensation layer obtained in Examples 1 and 2 and Comparative example

1, and a glass plate was adhered onto the surface of the optical compensation layer by roller, using an acrylic pressure-sensitive adhesive (thickness: 20 µm) so as to make a sample. Subsequently, the sample was subjected to a heat treatment test, a moistening treatment test and a

- 5 low-temperature treatment test, respectively, and then display irregularity of the sample within the plane after the treatments was observed. The methods thereof will be described below.

[0154] Heat treatment test

The sample was treated at 80°C for 200 hours using a drier.

10 [0155] Moistening treatment test

The sample was treated at 60°C and relative humidity (RH) of 90% for 200 hours.

[0156] Low-temperature treatment test

The sample was treated at -10°C for 200 hours.

15 [0157] Method for measuring display irregularity

As shown in FIG. 2, when the sample was segmentalized in nine, transmittance at nine measurement points within the plane was measured after the heat treatment test, the moistening treatment test and the low-temperature treatment test. A value of the display irregularity was obtained by an average value of the transmittance at the respective measurement points, which is represented by the following equation. The result will be shown in Table 1 below.

$$\text{Value of display irregularity} = [((1) + (3) + (7) + (9)) / 4] - [((2) + (4) + (6) + (8)) / 4]$$

In the equation, (1), (2), (3), (4), (5), (6), (7), (8) and (9) denote the transmittance at the respective measurement points.

[0158] Transmittance measurement

The transmittance measurement was performed using LUMINANCE COLORIMETER (trade name: BM-5A) manufactured by TOPCON Corporation.

30 [0159] Evaluation standard for visual observation

- A: Display irregularity was not found at all.
 B: Little display irregularity was found, which was not a problem in practical use.
 C: Display irregularity was found, which was a problem in practical use.

5 [0160]

(Table 1)

	Example 1	Example 2	Comparative example 1
glass transition temperature	50°C	90°C	120°C
heat	A (0.08)	B (0.20)	C (0.35)
moistening	A (0.05)	B (0.15)	C (0.35)
low-temperature	A (0.05)	B (0.15)	C (0.35)

Numerals in brackets in the table are values of display irregularity.

Industrial Applicability

10 [0161] As mentioned above, the optical compensation plate of the present invention is hardly affected by, for example, a shake during transportation, a shock applied in use or the like, therefore, the decoloration and the like caused by the occurrence of cracks can be prevented, and moreover, the occurrence of display irregularity within the plane and the like, which are caused by the deformation of the optical compensation layer occurring at the time of bonding or due to heat or the like, can be prevented, thus providing an excellent quality. Also, the polarizing plate of the present invention is useful for a liquid crystal panel, and suitable for the use in a liquid crystal display. The polarizing plate of the present invention can be used not only 15 in the liquid crystal display but also in self-light-emitting displays, for example, an electroluminescence (EL) display, a plasma display (PD) and a field emission display (FED).